Hypothermia, anemia, hyperglycemia, and severe hypoglycemia are significant prognostic indicators of death in client-owned ferrets (*Mustela putorius furo*)

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OBJECTIVE
To determine whether rectal temperature, Hct, or blood glucose at presentation were associated with all-cause mortality in ferrets (*Mustela putorius furo*).

ANIMALS
321 client-owned ferrets.

METHODS
A medical record database was searched for ferrets from January 2012 through September 2022. Records from 1,189 individual examinations were evaluated. Inclusion criteria were rectal temperature, Hct, and/or blood glucose measured at presentation and data on survival status 7 days postpresentation. Data were included from 321 ferrets from 571 examinations. Rectal temperature in 244 ferrets from 346 examinations, Hct in 181 ferrets from 277 examinations, and blood glucose in 260 ferrets from 420 examinations were available.

RESULTS
The odds of death for hypothermic ferrets (< 37.8 °C) were 3.72 times (OR, 3.72; 95% CI, 2.30 to 6.01) the odds of death for normothermic ferrets (37.8 to 40 °C). For every 0.56 °C below normal rectal temperature, the odds of death increased 1.49 times (OR, 1.49; 95% CI, 1.21 to 1.90). The odds of death for anemic ferrets (Hct < 33%) were 4.74 times (OR, 4.74; 95% CI, 1.70 to 13.21) the odds of death for ferrets with a normal Hct (33% to 57%). The odds of death for hyperglycemic ferrets (> 152 mg/dL) were 2.61 times (OR, 2.61; 95% CI, 1.29 to 5.30) the odds of death for normoglycemic ferrets (74 to 152 mg/dL). The odds of death for severely hypoglycemic ferrets (< 40 mg/dL) were 9.45 times (OR, 9.45; 95% CI, 3.18 to 28.12) the odds of death for normoglycemic ferrets.

CLINICAL RELEVANCE
Hypothermia, anemia, hyperglycemia, and severe hypoglycemia were significant prognostic indicators of death in ferrets. Further investigation into the causes and management of these derangements is warranted.

Keywords: blood glucose, ferret, hematocrit, prognostic indicator, rectal temperature

Ferrets are a popular pet in the US. According to the AVMA, over 300,000 households in the US own ferrets1; thus, there is demand for high-quality medical care for client-owned ferrets.

Prognosis plays a vital role in medical decision-making. Identifying prognostic indicators can lead to more informed decision-making, thereby optimizing patient management, improving clinical outcomes, and preventing undue suffering in cases where the prognosis is grave.2 Previous studies have been performed to evaluate prognostic indicators for all-cause mortality in zoological companion animal species including blood glucose and PCV in chelonians,3 rectal temperature in guinea pigs,4 and blood glucose, BUN, lactate, rectal temperature, and sodium in rabbits.5–9 Despite the value of prognostic indicator studies in other zoological companion animal species, there are no published studies evaluating prognostic indicators in client-owned ferrets.

Ferrets exhibit homeothermy, which refers to the physiologic capability to maintain a constant core body temperature, regardless of variations in environmental temperature.10 When a homeothermic
animal has a subnormal core body temperature, this is known as hypothermia. Hypothermia is classified as primary, which occurs following prolonged exposure to a cold environment, or secondary, which results when illness, injury, or drug administration alters the ability of an animal to thermoregulate and produce heat. As most physiologic processes in the body are optimized at a normal body temperature, reductions in core body temperature can negatively impact every organ system within the body, including the cardiovascular, gastrointestinal, hepatic, nervous, neuromuscular, renal, and respiratory systems, and deleterious effects may also be observed on acid-base balance, coagulation, and electrolyte levels. Conversely, hyperthermia describes an elevation in core body temperature above normal. Hyperthermia may be the result of a true fever, where the anterior hypothalamus increases the body’s set-point temperature, or can result from physiologic, pathologic, or pharmacologic changes that cause the body to gain more heat than it loses. Severe hyperthermia can lead to organ damage, disseminated intravascular coagulopathy, and death.

The primary function of mammalian erythrocytes is to deliver oxygen to all tissues within the body. Anemia is defined as a reduction in the oxygen-carrying capacity of blood due to decreases in hemoglobin concentration and erythrocyte mass. There are numerous underlying causes of anemia. The 3 primary mechanisms of anemia are blood loss, destruction of erythrocytes, and decreased erythropoiesis. An Hct measurement below the normal range is consistent with anemia. In contrast, polycythemia refers to an erythrocyte count above the normal range. Polycythemia can be classified as a relative polycythemia, caused by decreased plasma volume such as dehydration, or an absolute polycythemia, caused by increased erythrocyte mass. An Hct measurement above the normal range is consistent with polycythemia.

As in all mammal species, glucose serves as the principal source of energy for cells, and its metabolism is tightly regulated by multiple hormones. Previous studies in other species, including cows, dogs, horses, and rabbits, have shown that derangements in blood glucose, including both hypoglycemia and hyperglycemia, are associated with higher rates of mortality. In particular, hypoglycemia is a common clinical condition in ferrets. With a reported prevalence of 20% to 25% of all neoplasms in ferrets, pancreatic β-cell tumors (insulinomas) are a common disorder in this species; insulinomas lead to hypoglycemia through the release of excess insulin.

The objectives of this retrospective study were to determine if rectal temperature, Hct, or blood glucose at presentation to a veterinary teaching hospital were associated with an increased risk of mortality in client-owned ferrets. As rectal temperature, Hct, and blood glucose are commonly measured in client-owned ferrets, analyzing the prognostic value of these indices may improve patient care. Based on previous prognostic indicator studies in zoological companion animal species, the authors hypothesized that ferrets with hypothermia, anemia, hyperglycemia, and severe hypoglycemia would have a greater likelihood of death compared to ferrets with normal parameters.

### Methods

#### Case selection and medical records review

Medical records were reviewed for all domestic ferrets presented to a veterinary teaching hospital between January 1, 2012, and September 1, 2022. All ferrets that presented to the hospital were eligible for inclusion in the study, regardless of the service they presented to (emergency service, zoological medicine service). Records were excluded if rectal temperature, Hct, and blood glucose were not measured at presentation to the hospital or if there were no follow-up data available on survival status 7 days postpresentation.

Ferrets were classified as either alive or deceased (euthanized or died) at 7 days postpresentation to the hospital. Mortality at 7 days postpresentation was chosen based on prior studies in rabbits and guinea pigs, both commonly owned small mammal species. If information on survival status was not available in the medical record, clients were contacted to obtain follow-up information. If no follow-up information was obtained after one written email, the examination was excluded from the study.

Rectal temperature, Hct, and/or blood glucose at presentation were extracted from the medical record for each examination. If multiple measurements were recorded, only the initial recording was collected for each variable. As no research was found to support specific reference intervals for rectal temperature in ferrets, cut-offs were established based on 3 textbooks widely used in zoological companion animal medicine. Hypothermia was defined as a rectal temperature < 37.8°C, normothermia was defined as a rectal temperature of 37.8 to 40°C, and hyperthermia was defined as a rectal temperature > 40°C. Normal values for Hct and blood glucose were defined based on a previous reference interval study in healthy, sedated, neutered ferrets. For Hct, anemia was defined as a Hct < 33%, normal Hct was defined as a Hct of 33 to 57%, and polycythemia was defined as a H ct > 57%. Both spun and automated measurements of Hct were included in this study; while spun Hct values have been shown to be higher than automated Hct values due to plasma trapping between red blood cells, the difference is small and unlikely to be clinically significant. For blood glucose, hypoglycemia was defined as a blood glucose < 74 mg/dL, normoglycemia was defined as a blood glucose of 74 to 152 mg/dL, and hyperglycemia was defined as a blood glucose > 152 mg/dL. Hypoglycemia was further categorized as mild (60 to 73 mg/dL), moderate (40 to 59 mg/dL), and severe (< 40 mg/dL). Blood glucose measurements obtained by both portable blood glucose meters and laboratory analyzers were included in this study.
If the same sample was measured on both a portable blood glucose meter and a laboratory analyzer, the value measured on the laboratory analyzer was included in the study, as prior studies have shown poor agreement between portable blood glucose meters and laboratory analyzers.

Other data extracted from the medical record included individual identification number, date of presentation, sex, neuter status, age in months, body weight in grams, and health status. Ferrets were classified as healthy if they were presented for a wellness examination or elective procedure with no history of systemic disease and nonhealthy if they were presented with a new complaint of disease or injury, for wellness examination with a prior history of systemic disease, or to undergo a nonelective procedure.

**Statistical analysis**

For continuous variables, a Shapiro-Wilk test was used to analyze the data for normality, and a Mann-Whitney test was used to assess for differences between ferrets that survived and those that died. Continuous variables were summarized as median and IQRs based on their distribution. A χ² test with a Yates correction was used to assess for differences in survival status in male versus female ferrets. Logistic regression analysis was performed to evaluate the likelihood of death for derangements in rectal temperature, Hct, and blood glucose when compared to normal values. Rectal temperature was also evaluated as a continuous variable with logistic regression analysis to calculate the increase in the odds of death in hypothermic ferrets for every unit decrease in rectal temperature. Analyses were performed with the use of commercial software (Prism v9.5.1 [GraphPad Software LLC] and SAS v9.4 [SAS Institute Inc]). 

**P ≤ .05** was used for determining statistical significance.

**Results**

A total of 1,189 individual examinations from 615 individual ferrets occurred between January 1, 2012, and September 1, 2022. Of the 1,189 individual examinations performed, 488 (41.0%) had a rectal temperature documented at presentation, 350 (29.4%) had Hct, and 542 (45.6%) had blood glucose. Individual examinations were excluded either due to lack of a rectal temperature, Hct, and blood glucose measurement recorded (430/1,189, 36.2%) or lack of data on survival status 7 days postpresentation (188/1,189, 15.8%).

After exclusion, data from 571 individual examinations from 321 ferrets were included. Of the 321 ferrets, 121 (37.8%) were female, 199 (62.0%) were male, and 1 (0.3%) did not have a sex specified in the medical record. Twenty-seven (8.4%) ferrets were intact, 293 (91.3%) were neutered, and 1 (0.3%) did not have a neuter status specified. Fifteen (4.7%) ferrets were classified as healthy, and 306 (95.3%) were classified as nonhealthy. Body weight ranged from 360 to 2,130 grams with a median body weight of 910 grams. Of the 321 ferrets that presented, 205 (63.9%) were presented 1 time, 62 (19.3%) were presented 2 times, 25 (7.8%) were presented 3 times, 12 (3.7%) were presented 4 times, 5 (1.5%) were presented 5 times, 6 (1.9%) were presented 6 times, 4 (1.2%) were presented 7 times, 3 (0.9%) were presented 8 times, 1 (0.3%) was presented 12 times, and 1 (0.3%) was presented 15 times for a total of 571 individual examinations. The overall mortality rate at

### Table 1—Analysis of factors to determine association with mortality in a cohort of client-owned ferrets (*Mustela putorius furo*).

<table>
<thead>
<tr>
<th>Predictor</th>
<th>Alive (No. of Individuals)</th>
<th>Deceased (No. of Individuals)</th>
<th>OR (95% CI)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (mo), n = 571</td>
<td>53 ± 36</td>
<td>53 ± 41</td>
<td>.39</td>
<td>.39</td>
</tr>
<tr>
<td>Weight (g), n = 529</td>
<td>950 ± 370</td>
<td>788 ± 350</td>
<td>0.83 (0.57–1.21)</td>
<td>&lt; .0001</td>
</tr>
<tr>
<td>Sex, n = 570</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>271 (75.9%)</td>
<td>86 (24.1%)</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>154 (72.3%)</td>
<td>59 (27.7%)</td>
<td></td>
<td>.39</td>
</tr>
<tr>
<td>Clinical condition, n = 571</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Healthy</td>
<td>28 (100.0%)</td>
<td>0 (0.0%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nonhealthy</td>
<td>397 (73.1%)</td>
<td>146 (26.9%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rectal temperature, n = 346</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hypothermia</td>
<td>70 (50.7%)</td>
<td>68 (49.3%)</td>
<td>3.72 (2.30–6.01)</td>
<td>&lt; .0001</td>
</tr>
<tr>
<td>Normothermia</td>
<td>157 (79.3%)</td>
<td>41 (20.7%)</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Hyperthermia</td>
<td>7 (70.0%)</td>
<td>3 (30.0%)</td>
<td>1.64 (0.41–6.63)</td>
<td>.49</td>
</tr>
<tr>
<td>Hct, n = 277</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Anemia</td>
<td>8 (47.1%)</td>
<td>9 (52.9%)</td>
<td>4.74 (1.70–13.21)</td>
<td>.0029</td>
</tr>
<tr>
<td>Normal</td>
<td>139 (80.8%)</td>
<td>35 (19.2%)</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Polycythemia</td>
<td>73 (83.0%)</td>
<td>15 (17.0%)</td>
<td>0.87 (0.44–1.70)</td>
<td>.67</td>
</tr>
<tr>
<td>Blood glucose, n = 420</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hypoglycemia</td>
<td>105 (72.9%)</td>
<td>39 (27.1%)</td>
<td>1.46 (0.90–2.36)</td>
<td>.13</td>
</tr>
<tr>
<td>Mild hypoglycemia</td>
<td>45 (77.6%)</td>
<td>13 (22.4%)</td>
<td>1.14 (0.57–2.28)</td>
<td>.72</td>
</tr>
<tr>
<td>Moderate hypoglycemia</td>
<td>55 (79.7%)</td>
<td>14 (20.3%)</td>
<td>1.00 (0.52–1.95)</td>
<td>.99</td>
</tr>
<tr>
<td>Severe hypoglycemia</td>
<td>5 (29.4%)</td>
<td>12 (70.6%)</td>
<td>9.45 (3.18–28.12)</td>
<td>&lt; .0001</td>
</tr>
<tr>
<td>Normoglycemia</td>
<td>188 (79.7%)</td>
<td>48 (20.3%)</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Hyperglycemia</td>
<td>24 (60.0%)</td>
<td>16 (40.0%)</td>
<td>2.61 (1.2–5.30)</td>
<td>.008</td>
</tr>
</tbody>
</table>

Continuous data reported as median ± IQR.
7 days postpresentation of all ferrets from all visits was 25.6% (146/571).

Survival data were evaluated for each parameter analyzed (Table 1). Ferrets that were hypothermic (<37.8 °C) had a significantly higher likelihood of mortality compared to ferrets that were normothermic (37.8 to 40 °C; Figure 1). For every 0.56 °C decrease below normal rectal temperature, the odds of death increased 1.49 times (OR, 1.49; 95% CI, 1.21 to 1.90). Ferrets that were anemic (Hct < 33%) had a significantly higher likelihood of mortality compared to ferrets with a normal Hct (33 to 57%; Figure 2). Ferrets that were hyperglycemic (> 152 mg/dL) had a significantly higher likelihood of mortality compared to ferrets that were normoglycemic (74 to 152 mg/dL; Figure 3). Overall, there was no significant difference in the likelihood of mortality for ferrets that were hypoglycemic (< 74 mg/dL) compared to ferrets that were normoglycemic; however, when subcategories of hypoglycemia were analyzed, ferrets that were severely hypoglycemic (< 40 mg/dL) had a significantly higher likelihood of mortality compared to ferrets that were normoglycemic (Figure 4).

**Figure 1**—Survival status of client-owned ferrets (Mustela putorius furo) by rectal temperature on presentation to a veterinary teaching hospital between January 1, 2012, and September 1, 2022. Ferrets that were hypothermic had a significantly higher likelihood of mortality compared to ferrets that were normothermic (P ≤ .0001).

**Figure 2**—Survival status of client-owned ferrets (Mustela putorius furo) by Hct on presentation to a veterinary teaching hospital between January 1, 2012, and September 1, 2022. Ferrets that were anemic had a significantly higher likelihood of mortality compared to ferrets that were normothermic (P ≤ .0001).

**Figure 3**—Survival status of client-owned ferrets (Mustela putorius furo) by blood glucose on presentation to a veterinary teaching hospital between January 1, 2012, and September 1, 2022. Ferrets that were hyperglycemic had a significantly higher likelihood of mortality compared to ferrets that were normoglycemic (P ≤ .01).

**Figure 4**—Survival status of hypoglycemic client-owned ferrets (Mustela putorius furo) on presentation to a veterinary teaching hospital between January 1, 2012, and September 1, 2022. Ferrets that were severely hypoglycemic had a significantly higher likelihood of mortality compared to ferrets that were normoglycemic (P ≤ .0001).
Discussion

Based on the results presented in this study, there was a significant difference in weight between ferrets that survived and ferrets that died. As there were no differences in age or sex, it is possible that the differences found for body weight were a result of the differences in body condition with chronic disease states. Body condition scoring was not routinely documented within the medical records; therefore, it was not analyzed in the current study. Neoplasia is a common cause of disease in domestic ferrets, with insulinomas, adrenocortical neoplasms, and lymphomas occurring most commonly. In all species, including ferrets, cachexia is a well-documented paraneoplastic syndrome, consisting of progressive weight loss and tumor anemia, neoplasia, nutritional deficiencies, surgery, toxins, and trauma. As many of these disease processes carry a poor prognosis, the higher rates of mortality in ferrets with anemia were likely secondary to severe underlying disease.

Rectal temperature, Hct, and blood glucose measured at presentation were significantly associated with survival status in client-owned ferrets. Hypothermia, anemia, hyperglycemia, and severe hypoglycemia were identified as prognostic indicators of death. While healthy ferrets were unlikely to die within 7 days of presentation, those that presented with illness or injury were at risk of mortality within 7 days. Due to its association with mortality and ease of measurement, at a minimum, rectal temperature should always be measured during physical examinations of ill or injured ferrets. While it is inappropriate to recommend euthanasia based solely on rectal temperature or clinicopathologic findings, identifying patients with a higher likelihood of mortality may help to guide clinical decision-making.

Understanding the mechanisms by which hypothermia, anemia, hyperglycemia, and severe hypoglycemia are associated with increased odds of mortality in client-owned ferrets is beyond the scope of the present study. A possible explanation for the increased odds of mortality in hypothermic ferrets is that hypothermia represents a state of shock. Small mammals frequently become hypothermic in early compensatory stages of shock; due to their small size, ferrets are prone to developing dehydration and hypovolemic shock secondary to decreased water intake or excessive fluid losses. A further explanation is that hypothermia directly decreases the chances of survival. As most physiologic processes in the body are optimized at a normal body temperature, reductions in core body temperature can disrupt the physiological processes of all organ systems.

For example, hypothermia causes detrimental changes to the cardiovascular system including bradycardia, hypotension, cardiac arrhythmias, decreased cardiac output, and asystole. There are numerous underlying causes of anemia in ferrets. Some of the more common causes include endocrine disease, gastrointestinal blood loss, hyperestrogenism, immune-mediated hemolytic anemia, neoplasia, nutritional deficiencies, surgery, toxins, and trauma. As many of these disease processes carry a poor prognosis, the higher rates of mortality in ferrets with anemia were likely secondary to severe underlying disease.

Stress hyperglycemia is a well-documented phenomenon in both human and veterinary patients. The term “stress hyperglycemia” refers to a transient elevation in blood glucose in patients without a previous history of diabetes due to an altered metabolic state secondary to acute illness. It results from high levels of counterregulatory hormones (glucagon, growth hormone, catecholamines, and glucocorticoids) and inflammatory cytokines (tumor necrosis factor-α and IL-1), which lead to insulin resistance, increased hepatic gluconeogenesis and glycogenolysis, and impaired insulin-mediated glucose uptake into skeletal muscle. In nondiabetic human patients, hyperglycemia during critical illness is a common occurrence in the intensive care unit (ICU). One study evaluating human patients with acute myocardial infarction reported an incidence of 71%. While hyperglycemia can develop in critically ill patients secondary to severe underlying disease, the presence of hyperglycemia during critical illness is also associated with a number of adverse consequences in human patients. Hyperglycemia adversely affects fluid balance, predisposes to infection, increases morbidity after acute cardiovascular events, and increases the risk of renal failure, polyneuropathy, and mortality in human ICU patients. Thus, both underlying illness and physiologic consequences of hyperglycemia could lead to increased mortality in client-owned ferrets.

Although hypoglycemia is a common clinical condition in pet ferrets, based on the present study, only severe hypoglycemia (< 40 mg/dL) was a prognostic indicator for death within 7 days of presentation to a veterinary teaching hospital. In a study of human patients with type 2 diabetes, severe hypoglycemia was associated with an increased risk for macrovascular events, microvascular events, and death from both cardiovascular and noncardiovascular causes; thus, adverse physiologic consequences of severe hypoglycemia may lead to increased mortality in client-owned ferrets. There are numerous causes of hypoglycemia in ferrets, including heatstroke, liver disease, neoplasia, sepsis, and starvation; however, the most common cause is insulinoma. In ferrets with insulinoma, clinical signs often improve rapidly following the provision of a meal or intravenous administration of dextrose. It is possible that mild and moderate hypoglycemia did not result in mortality within 7 days because the most common cause of hypoglycemia in ferrets is insulinoma, which is often a manageable condition. Therefore, mild to moderate hypoglycemia alone is not a reason to recommend euthanasia, especially if clinical signs respond to glucose supplementation.

The retrospective nature of this study provided several limitations. Less than half (41.0%) of the medical records evaluated had a rectal temperature documented, and they rarely stated why it was not recorded. If the ferret presented to the hospital apparently healthy or minimally ill, the clinician may have elected not to perform a rectal temperature due to minimal concern for systemic disease. The potential exclusion of apparently healthy or minimally ill
ferrets may have introduced bias into this dataset and led to greater mortality rates than would be expected if rectal temperatures had been measured in all animals on presentation. Additionally, all temperatures that did not have a methodology designated within the medical record were assumed to be rectal temperatures, as this was the most common methodology utilized. Axillary, inguinal, or tympanic temperatures mistakenly recorded as rectal temperatures could skew temperature measurements and change the results of this study, as a prior study in ferrets found disagreement between rectal temperature and these other methodologies, with these other methodologies generally measuring lower compared to rectal temperatures. As previous studies have documented hypothermia as a significant predictor of mortality in rabbits and guinea pigs, it is also possible that clinicians aware of these prior studies may have been more likely to recommend euthanasia for hypothermic ferrets, further biasing the dataset.

Similarly, less than half of the medical records evaluated had Hct or blood glucose (29.4% and 45.6%, respectively) measurements documented. As these tests are more invasive than measuring a rectal temperature, they were likely not performed unless there was clinical suspicion for clinicopathologic abnormalities or if owners elected routine blood work screening during wellness examination. Therefore, the potential exclusion of apparently healthy or minimally ill ferrets may, again, have introduced bias into the dataset and led to greater mortality rates than would be expected in the general population. Additionally, the small population of anemic ferrets included in this study precluded analysis of anemia and its association with mortality and ease of measurement. As these other methodologies generally measuring lower compared to rectal temperatures, as this was the most common methodology utilized. Axillary, inguinal, or tympanic temperatures mistakenly recorded as rectal temperatures could skew temperature measurements and change the results of this study, as a prior study in ferrets found disagreement between rectal temperature and these other methodologies, with these other methodologies generally measuring lower compared to rectal temperatures. As previous studies have documented hypothermia as a significant predictor of mortality in rabbits and guinea pigs, it is also possible that clinicians aware of these prior studies may have been more likely to recommend euthanasia for hypothermic ferrets, further biasing the dataset.

As the ferrets included in this study were presented to a tertiary referral hospital, it is likely that this population differs significantly from the general population of ferrets. Although this teaching institution admits nonreferral cases, including wellness appointments, only 28 of 571 (4.9%) individual examinations were performed on ferrets classified as healthy. As all ferrets were eligible for inclusion in this study, including those presented for emergency care, the mortality rates in this study are likely higher than would be expected in the general population. Additionally, as there is high clinician turnover at a veterinary teaching hospital, and data were collected from both the emergency service and the zoological medicine service, there was likely significant variability in the rectal temperature collection method, timing of rectal temperature collection during the physical examination, timing of Hct and blood glucose measurement following presentation to hospital, as well as devices and methodologies used to measure these parameters. As all individual examinations were included in this study, some ferrets were included multiple times in the dataset, which may have introduced bias. Moreover, the decision to evaluate mortality at day 7 was based on prior prognostic indicator studies in rabbits and guinea pigs, both commonly owned small mammal species; however, if a different timeframe was chosen to assess survival status, the results may have differed. Finally, animals that survived to discharge were more likely to be lost to follow-up compared to animals that died in hospital, which may have further increased mortality rates compared to the general population. If owners were able to be contacted to collect follow-up information, there was potential recall bias present, as owners may not have been able to accurately remember whether their ferret was alive or not at 7 days postpresentation.

Investigating the causes and management strategies of hypothermia, anemia, hyperglycemia, and severe hypoglycemia was beyond the scope of the present study. Future areas of research should explore the causes of hypothermia, anemia, hyperglycemia, and severe hypoglycemia, the relationships between these derangements and increased mortality, and the treatment of these derangements in domestic ferrets. Prospectively designed studies should also be performed to evaluate additional blood biochemical parameters including BUN, sodium, and lactate, which have been shown to act as prognostic indicators of survival in rabbits. In conclusion, hypothermia, anemia, hyperglycemia, and severe hypoglycemia were significant prognostic indicators of mortality in ferrets. Due to its association with mortality and ease of measurement, at a minimum, a rectal temperature should be measured during physical examinations of ill or injured ferrets.

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